



## Making Sense of Iran's Stocks of 3.5 and Near 20 percent LEU

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The Joint Comprehensive Plan of Action (JCPOA) imposes restrictions on Iran's stockpile of low enriched uranium (LEU). More specifically, it imposes a 300 kilogram (kg) hexafluoride cap on Iran's stock of less than 3.67 percent LEU for 15 years, and calls for the removal or downblending to an enrichment level of 3.67 percent or less of all near 20 percent LEU that is not in fabricated, usable Tehran Research Reactor (TRR) fuel plates. Iran must comply with these restrictions by Implementation Day.

Recently, Ali Akbar Salehi, head of the Atomic Energy Organization of Iran, [stated](#) that Iran had "imported 137 tonnes of yellowcake from Russia and will export about nine tonnes of enriched uranium to Russia within the next days." However, he did not provide the enrichment level of this LEU or its units, making it difficult to assess what fraction of LEU will be exported in the near future. To better assess this statement, we developed a breakdown of Iran's stocks of 3.5 and near 20 percent LEU, both in terms of  $UF_6$  and uranium mass. Depending on the units, Salehi's statement raises questions about whether this shipment will suffice to meet the conditions of the JCPOA or more shipments will be necessary involving both 3.5 percent and near 20 percent LEU.

### 3.5 Percent LEU

Based on International Atomic Energy Agency (IAEA) data, as of November 2015, Iran produced about 16,142 kilograms of 3.5 percent LEU hexafluoride. Out of this cumulative stockpile, about 3,490 kg of LEU hexafluoride were used to make near 20 percent LEU and for research. Another 4,334 kg of LEU hexafluoride were fed into the Enriched  $UO_2$  Powder Plant (EUPP) for conversion into oxide form, leaving a hexafluoride stock of 8,318 kg (or 5,573 kg if only the uranium mass is measured).

It is important to remember that this stock of LEU is growing since Iran continues to enrich uranium in a certain number of IR-1 centrifuges. Based on Iran's past enrichment trends, it produced about 200 kg of 3.5 percent LEU hexafluoride in the last month, which is about 134 kg of 3.5 percent LEU in terms of uranium mass. Therefore, to date, Iran's total stock of 3.5 percent LEU hexafluoride is about 8,500 kg in hexafluoride mass or 5,695 kg in uranium mass.

In addition to the LEU in hexafluoride form, Iran has LEU in other forms. Of the amount fed into the EUPP, as of December 17, 2015 Iran had produced 2,676 kg (U-mass)  $LEUO_2$ . This amount is equivalent to about 3,994 kg LEU hexafluoride, implying that another 340 kg ( $UF_6$  mass), or 228 kg LEU (uranium mass), are in various chemical forms at the EUPP (see Table 1 and Figure 1). Overall, the EUPP has recently worked considerably better than in the past.

To meet the condition of the JCPOA, Iran must limit its stock to 300 kg of 3.5 percent LEU hexafluoride, or about 200 kilograms of LEU (uranium mass). As a result, Iran would be expected to export virtually all of its mid-December stock of about 8,500 kg 3.5 percent LEU hexafluoride and 2,676 kg (uranium mass) 3.5 percent  $LEUO_2$ . Totaling these values requires the use of the same units. If that is done, **Iran would**

**be expected to export almost 8,370 kilograms (uranium mass) of 3.5 percent LEU or 12,500 kilograms of 3.5 percent LEU hexafluoride.** In addition, if Iran wants to reach its cap under the JCPOA, it will need to export additional, albeit small, amounts of the LEU inside the EUPP conversion plant which currently amount to 340 kg hexafluoride mass.

The monthly rate of LEU production is expected to decrease to about 100 kg per month as Iran reduces the number of its centrifuges under the JCPOA. Because of the 300 kg cap, Iran will need to regularly send LEU out of Iran, blend it down, or pause in enriching uranium.

### **Near 20 percent LEU Stocks**

Iran holds a relatively large stock of near 20 percent LEU. As of December 2015, Iran possessed about 228 kg of near 20 percent LEU (uranium mass). Although none of this material is in hexafluoride form (UF<sub>6</sub>), it is in several other forms, based on the November 2015 IAEA safeguards report and the December 2015 IAEA Joint Plan of Action monthly report (see table 2 and figure 2):

- 40.9 kg remain in pure oxide powder form;
- 35.25 kg are believed to be in the process of TRR fuel manufacturing;
- 51.5 kg are in TRR fuel assemblies; about 20 kg are irradiated;
- 39.4 kg are in the recovery process;
- 54.8<sup>1</sup> kg are in scrap and waste; and
- 5.75 kg are used in the manufacture of MIX miniature fuel plates; the actual amount in MIX plates is not given by the IAEA. The MIX plates are used as targets in the TRR to make medical isotopes.

Based on the JCPOA, Iran can keep the amount of LEU in usable TRR plates. Thus, as of November 2015 Iran is assured of keeping 51.5 kg (uranium mass) of near 20 percent LEU in TRR fuel plates plus up to a few kilograms in MIX plates. Subtracting these amounts from the total of 228 kg LEU leaves about 175 kg (uranium mass) that is not in TRR fuel plates as of November.<sup>2</sup>

Iran likely continues to make TRR fuel plates, although the rate of production during the last month has not been published by the IAEA or Iran. Based on earlier rates, the amount made into usable fuel plates during the past month is expected to be relatively small. In any case, Iran is expected to send out up to 175 kilograms of near 20 percent LEU. The exact amount will depend on how many usable TRR fuel plates Iran makes by Implementation Day.

A concern relates to the possible interpretation of the provisions relating to the near 20 percent LEU in scrap and waste. According to Annex 1 of the JCPOA: by Implementation Day, *“All uranium oxide enriched to between 5% and 20% will be fabricated into fuel plates for the Tehran Research Reactor or transferred, based on a commercial transaction, outside of Iran or diluted to an enrichment level of 3.67% or less. Scrap oxide and other forms not in plates that cannot be fabricated into TRR fuel plates will be transferred, based on a commercial transaction, outside of Iran or diluted to an enrichment level of 3.67% or less.”* The first sentence is the main condition, which means that in the case of the second, subordinate sentence, any fabrication has to occur before Implementation Day or the LEU must be exported from Iran or blended down. One issue may be whether Iran can keep LEU in fuel plates that

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<sup>1</sup> A small percentage of this number could still be in process.

<sup>2</sup> The amount of near 20 percent LEU present in TRR fuel plates was provided by the IAEA in its November 2015 Safeguards Report. During December 2015, it is likely that Iran fabricated a few more LEU fuel plates. However, the exact amount is not provided by the IAEA or Iran.

are defective or not of sufficient quality to be used in the TRR. Any Iranian attempt to keep this LEU should be opposed, as such plates would be considered scrap and not fuel.

It is imperative that all of Iran’s near 20 percent LEU in scrap and waste be deemed unfit for use in TRR fuel and sent out of Iran prior to Implementation Day, since dilution would likely be overly difficult. Near 20 percent LEU in powder form must be made into fuel by Implementation Day; the remainder must be shipped out or diluted by then. The material in intermediate forms either in the recovery or fuel fabrication process must be either manufactured into TRR fuel assemblies by Implementation Day or shipped out.

## Conclusion

It is imperative to scrutinize the process of removing LEU from Iran to ensure that the JCPOA’s conditions are implemented. By Implementation Day, Iran’s large domestic 3.5 percent LEU stock must be reduced to a maximum of 300 kg (hexafluoride mass). Its near 20 percent stock will need to be reduced by up to 175 kilograms (uranium mass) and confined to only usable TRR fuel and target plates.

After a final inventory in Iran of near 20 percent LEU is established, breakout times will need to be re-examined. A sizeable amount of the TRR fuel plates will contain unirradiated LEU; currently about 30 kg are unirradiated. This LEU is re-convertible to hexafluoride form in a straightforward manner, making it available within months for enrichment to weapons-grade in a breakout. Depending on the final size of this stock, breakout times could shrink by several months.

## Iran’s Stock of 3.5 percent LEU

As of November/December 2015

	Plant	Kg UF <sub>6</sub>	Kg U-mass
<b>LEU produced</b>	Fuel Enrichment Plant (FEP)	15,525	10,401.7
	Pilot Fuel Enrichment Plant (PFEP)	136.4	91.4
	Fordow Fuel Enrichment Plant (FFEP)	364.6	244.3
	Produced from ~20 percent downblending	115.6	77.4
	<i>Subtotal</i>	<i>16,141.6</i>	<i>10,814.8</i>
<b>LEU Used</b>	Fed into PFEP	- 1,630.8	-1,092.6
	FED into FFEP	- 1,806	-1,210
	Used for R&D at UCF	- 53	-35.51
	Fed into EUPP	-4,334	-2,903.7
	<i>Subtotal</i>	<i>- 7,823.8</i>	<i>- 5,242</i>
<b>Total LEU in UF<sub>6</sub> Form</b>		<b>8,317.8<sup>3</sup></b>	<b>5,573</b>
<b>LEU Oxide Produced at EUPP</b>	Oxide	+3,994	+2,676
	Intermediate Forms	+340	+227.8
<b>TOTAL</b>		<b>12,651.8</b>	<b>8,476.8</b>

Table 1. Iran’s Stock of 3.5 percent LEU as of November/December 2015.

<sup>3</sup> This number, based on step-by-step calculations, differs slightly from the amount given by the IAEA in its latest report, which is 8,305.6 kilograms, for a difference of 12.2 kilograms. This difference was also present in every report dating back to February 2014. The difference in the November 2013 report was 0.4 kilograms. The reason for the differences are unclear.

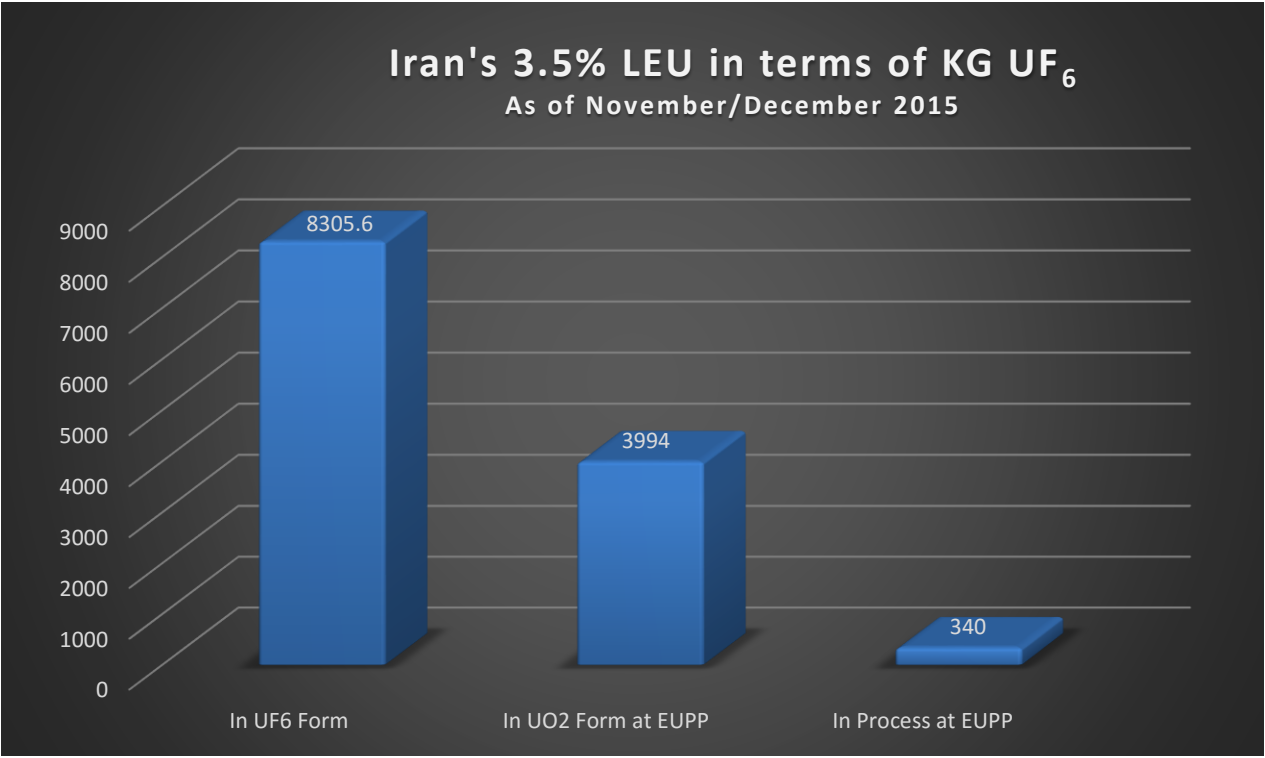


Figure 1. Iran’s Stock of 3.5 percent LEU as of November/December 2015 (kg of UF<sub>6</sub>).

### Iran’s Stock of Near 20 percent LEU

As of November/December 2015

	Equivalent Kg UF <sub>6</sub>	Kg U-mass
Pure LEU Oxide Powder (U <sub>3</sub> O <sub>8</sub> )	61	40.9
In TRR Fuel Assemblies	76.9	51.5
In TRR Fuel Manufacturing	52.6	35.25
In Recovery Process	58.8	39.4
In Scrap/Waste	81.8	54.8
In MIX Miniature Fuel Plates	8.6	5.75
<b>TOTAL</b>	<b>339.7</b>	<b>227.6</b>

Table 2. Iran’s Stock of near 20 percent LEU as of November/December 2015.

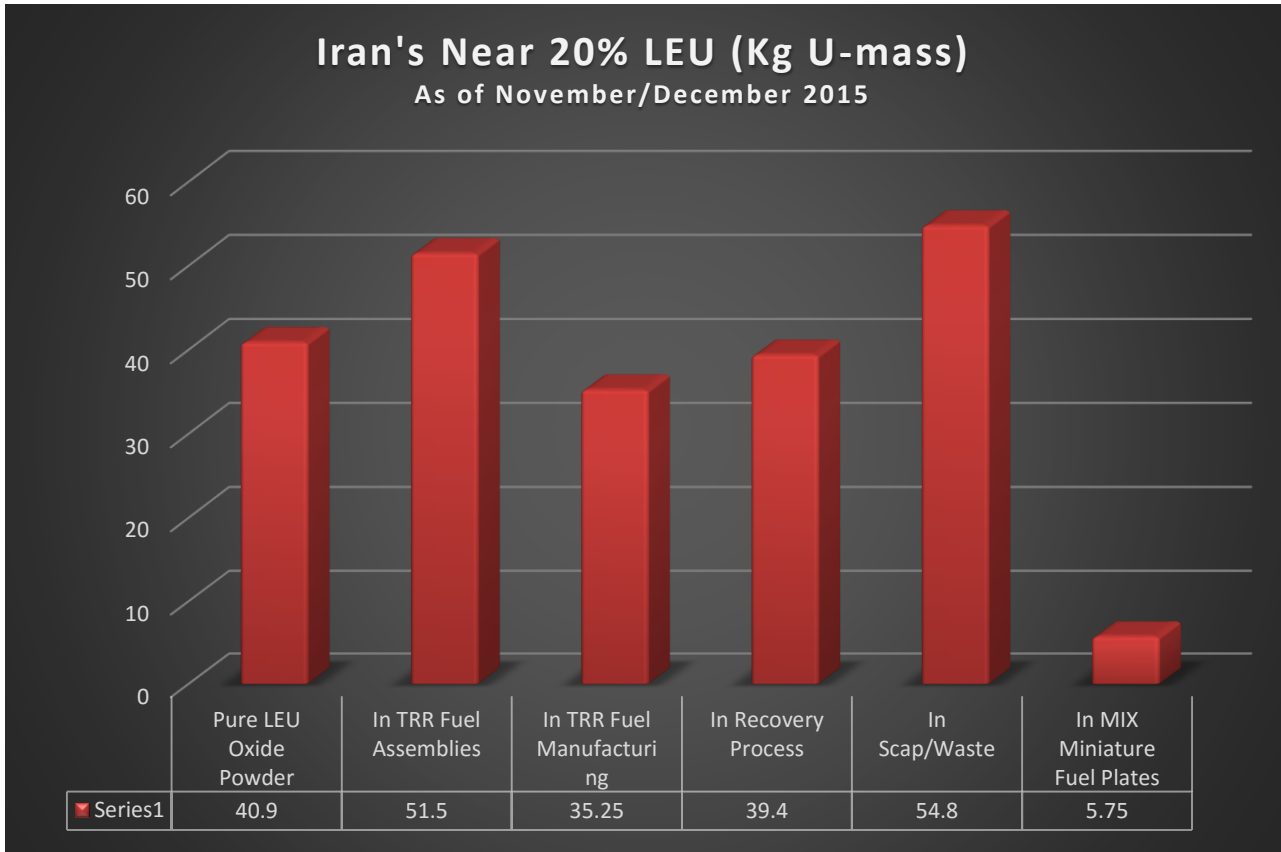


Figure 2. Iran's Stock of near 20 percent LEU as of November/December 2015 (kg of U-mass).